CONCLUSION.

Recapitulating in brief, it may be said that, whatever particular theory of osteogenesis may be the true one, the following points have proved valuable in practice:

The area of the graft must be kept scrupulously aseptic, and free from unnecessary blood clot. Adequate blood supply is necessary to the growth of the graft.

The graft must be placed in close apposition to raw surfaces of the bone with which it is to unite.

The whole region must be kept fixed for a long period for undisturbed organization to take place.

The bone graft should be autogenous, and it is better that it should include both periosteum and medulla wherever this is possible, for both these aspects of the bone afford facilities for the growth of new blood vessels.

Surgeons should have patience, for union is often delayed, and hasty conclusions that union is not going to take place, and consequent relaxation of strict fixation of the part, may convert a case of delayed union into one of non-union.

After any of these procedures it is essential to fix the limb absolutely to let new vessels grow undisturbed by chance movements, for the idea of the operation is that all the transplanted bits of bone shall become vascularized.

As a general rule, the limb should be kept fixed and undisturbed for at least twice the time necessary for union of the same bone in an ordinary simple fracture.

I often see cases which have been operated on, often plated, by some other surgeon, in which splints have been removed at the end of a few weeks, and the case has been regarded as a failure because union has not taken place.

There is no definite time within which a fracture will unite. The times given in textbooks are understated as applied to the majority of cases. For example, I may quote the case of a patient, seen in 1908, with an ununited fracture of the humerus of twelve months' duration, which was treated by the "hammer and dam" method, but had to be kept still for nearly six months before the bones united. The ultimate union was absolutely satisfactory. Operative procedures had previously failed. This question of the consolidation of fractures has been discussed in a previous paper. The wounds received in this war have brought the surgery of septic bones very much into the foreground, and bone grafting will have to be very extensively practised. We must be careful to allow a sufficient time to elapse before proceeding to this operation. It is difficult to formulate an exact rule as to when the operation should be performed, for we seem never to be quite free from the danger of recrudescent sepsis. My habit is to wait for at least six months after a sinus is closed, during which time and for a variable period afterwards efforts can be made to improve the general nutrition of the limb. It frequently happens that during this delay union of the fragments takes place, and no transplantation is needed. Early operation is to be discouraged from every point of view, and failure to observe this fact has resulted in many a tragedy. It is very exceptional, unless there has been a great loss of bone, for non-union to persist in fractures which are the seat of the type of suppuration met with at this time.

SIR ALEXANDER RUSSELL SIMPSON, M.D., of Edinburgh, left £12,332.

SUTTON, of Kansas City, relates in the *Journal of the American Medical Association*, January 15th, the case of a girl of 18, a stenographer, intelligent, mentally alert, and with no stigmata of degeneration, who acquired a habit of twisting the eyelashes and the hair of the eyebrows and scalp, and breaking them off short with the edge of the thumb and forefinger a little above the surface of the skin. She did not pluck out the hairs as in "trichotillomania" or *tic de l'épilation*. The result was the appearance of bald patches on the scalp with short stumps of healthy hair, whilst the hairs around were perfectly normal. The baldness was noted by the patient's friends when she was sixteen. When worried or idle she would gaze into space for hours at a time and twist and snap her hair, throwing away one hair after another, but it was only when under treatment that she admitted that the baldness was artificial. When a child she sucked her fingers and bit her nails. Under a course of psychotherapy the patient's condition greatly improved within a few weeks.

ON THE LIFE-HISTORY OF ASCARIS LUMBRICOIDES.

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Preliminary Note.

The development of *Ascaris lumbricoides* is at present almost universally considered to be direct. It is well known that the eggs passed in the faeces of man undergo development in the outer world up to the formation of a motile vermiform embryo. The egg containing this embryo may readily reach the alimentary canal of man, and it is supposed that it there hatches, and that the larva, having escaped, develops in this site into the adult. This theory is based on the work of Davaine,[1] Grassi,[5] Calandruccio,[6] Lutz,[7] Epstein,[8] Jammes and Martin,[10] Martin,[11] and Wharton.[12] I have not at present access to the works of these authors in the original with the exception of the articles of Jammes and Martin and of Wharton. Summaries sufficient for the present purpose are, however, available in the textbooks of Leukart[4] as regards Davaine, of Railliet,[13] Manson,[14] Clifford Allbutt,[15] and Castellani,[16] as regards the later writers.

Davaine administered ripe eggs to rats, and found that after twelve hours free live larvae were to be found in the lower part of the small intestine. He also introduced ripe and unripe eggs in glass capsules closed with linen into the alimentary canal of the dog and found that after the lapse of a certain period the ripe eggs had disappeared, whereas the unripe eggs remained. He concluded that hatching and development occurred in the alimentary canal of the definitive host.

Grassi administered ripe eggs to himself, and two months later found eggs in his stools. Calandruccio infected a child of 10 which had previously suffered from worms, but had been relieved of these parasites by anthelmintics. Lutz fed an adult on ripe eggs, and found evidence of the subsequent appearance of adult worms. Epstein's work is unfortunately not available even in summary, but from the context of the references it is clear that he successfully infected man.

Jammes and Martin worked on the line of experimental hatching of ripe eggs in artificial and natural solutions, and found that hatching took place readily and *en masse* in 0.8 per cent. salt solution (which they consider to be an alkaline solution) at 37° to 40° C. Martin found that the embryos of the ascarids from the calf, pig, horse and dog hatched best in alkaline solutions, and that when developed eggs were introduced into the alimentary canal of an animal they passed through the stomach unaffected and only hatched after they had been subjected to the action of the alkaline juices of the intestine (Ext. quoted from Wharton).

Wharton states that direct infection can take place, but that the embryos must be "completely developed." He does not give the period necessary to secure this complete development.

In spite of the general acceptance of the theory there is a considerable bulk of evidence against it.

Davaine[1] administered three to four hundred ripe eggs to an ox—an animal which is stated to harbour *Ascaris lumbricoides*—and found that after four months no worms were present in the intestine. Küchenmeister[2] experimented with a dog, which, however, escaped from his observation. Leukart[4] fed a rabbit on ripe eggs, and found no worms after ten days; a dog was also treated, and was equally unresponsive after fourteen days. This very experienced helminthologist also fed a pig for three weeks on several thousand ripe eggs, and did not find any worms on section. An experiment on man was arranged in 1857, but it is not clear that it was carried out. He also administered to a horse the eggs of *Ascaris megalocephala*; to a dog those of *Ascaris marginata*; to a cat those of *Ascaris mystax*, with invariably negative results.

Leukart, therefore, maintained that the life-history of *Ascaris lumbricoides* would be found to be completed by an alternation of hosts. He supported this opinion by the facts known with regard to (1) *Ascaris acus*, which is found as an encysted larva in *Leuciscus alburnus*, and in the

adult form in the pike, and (2) a larval *Ascaris* found encysted in the muscles of the mole, which, when administered to the buzzard, continues to develop, although it does not yet become adult. He considered that Davaine's rat experiment, if correctly described, did not point to the direct development of the worm, but to the fact that the rat was an intermediate host. He pointed out the ease with which the larvae liberated in the faeces of the rat could be conveyed to the intestine of the definitive host—man. He attempted to confirm the experiment, but employed a mouse in place of a rat, and found that the eggs were passed unaltered in the faeces of the mouse. He therefore abandoned this line of research. He attempted to find the intermediate host among invertebrate animals, experimenting with a number of insects, snails, and earth-worms, but without success. Von Linstow[12] suggested that *Julus guttulatus* might be the intermediate host.

Ascariasis, both in man and the pig, is of extraordinary frequency in the colony of Hong Kong and in South China generally. I therefore, while stationed in this colony, had an unusual opportunity of studying the subject. I commenced experiments in the spring of 1915. Two young pigs were obtained, aged two months. The faeces of both were examined and found to be free of *Ascaris* eggs.

Pig A was fed throughout the course of the experiment on tinned milk and rice flour. Large quantities of ripe eggs from the *Ascaris* of the pig were administered to it on thirteen occasions between September 20th and December 6th, 1915. The age of the eggs employed varied from 26 to 64 days, and they invariably contained well-developed and motile embryos. They had been incubated at a temperature between 25° and 30° C. in a damp atmosphere. They were administered under varying conditions, after food and after twelve hours' starvation, with and without the addition of sodium bicarbonate. The total number of eggs used must have greatly exceeded several thousand. This pig was killed on December 15th, 1915. One small *Ascaris* only was found in its intestine.

Pig B was fed between September and December, 1915, in the same manner as Pig A, on tinned milk and rice flour; from January, 1916, onward he was fed on boiled rice and vegetables. Between September 27th and December 2nd, 1915, large quantities of ripe eggs from the *Ascaris* of man were administered to him on nine occasions. The age of the eggs varied from 22 to 106 days. They also had been kept during the colder months in an incubator between 25° and 30° C. in a damp atmosphere. The faeces of the pig were repeatedly examined for *Ascaris* eggs but none were found. Between January 5th and February 27th, 1916, large quantities of eggs from the *Ascaris* of the pig were administered, the age of the eggs varying between 17 and 73 days. The faeces of this animal were again examined repeatedly, but up to April 17th no eggs of *Ascaris* were found.

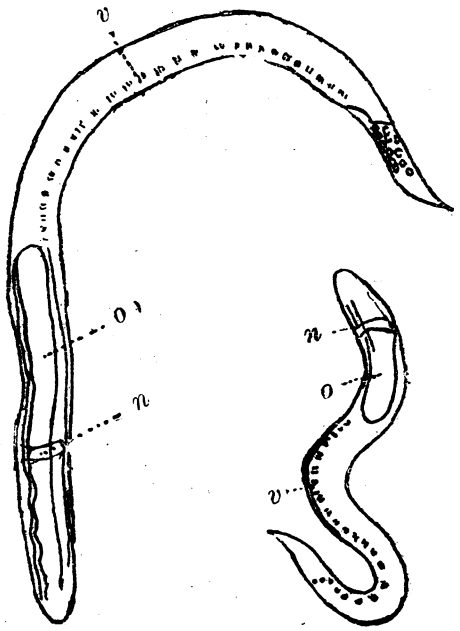

Fig. 1.—Embryo expressed from egg (× 680). *o*, Oesophagus; *n*, nerve ring; *v*, ventral longitudinal line.

Fig. 2.—Larva from lung of mouse four days after infection (× 385). *o*, Oesophagus; *n*, nerve ring; *v*, ventral longitudinal line.

These two series of experiments thus strongly confirmed the negative finding of Leukart's experiment with the pig.

On April 6th, 1916, I took up Davaine's experiment with the rat. Four specimens of *Mus decumanus* albino had been obtained. Their faeces had been repeatedly examined and no eggs of nematodes had been found.

At 2 p.m. on April 6th ripe eggs of *Ascaris lumbricoides* from man were administered to all four rats. The faeces passed between 8 p.m. on the 6th and midday on the 7th were found to contain free larvae of *Ascaris lumbricoides*. These larvae moved in a languid manner in normal salt solution. Eggs of the *Ascaris* of the pig were administered to all four rats on April 7th and 9th, and to Rats A, B, and D on April 10th. Eggs of the *Ascaris* of man were again given to Rat C on April 10th. The faeces continued to contain free *Ascaris* larvae. Specimens of the faeces were preserved in an incubator between the temperatures of 25° and 30° C. Live larvae were found in these specimens after the lapse of three days. The experiment of Davaine was therefore fully confirmed.

On April 12th a further development of the experiment took place. Rat C died, but I was prevented from examining this rat or observing the remaining three until April 15th. Rat C was preserved during the interval in an ice chest. On April 15th it was examined. A small quantity of blood had escaped from its nostrils. No nematodes, larval or adult, were found in the stomach or intestines. The lungs were found to be congested. Portions were removed and teased out in normal salt solution. Numerous nematode larvae in active movement escaped from the tissue. The liver was also examined and a small number of larvae found. No larvae were found in the spleen or kidneys.

The Rats A, B, and D were on this day obviously suffering from the pneumonia. A small quantity of blood was issuing from the nostrils of B and D, and all three were breathing in a rapid and exaggerated manner.

On April 16th Rat D was killed. The same nematode larvae were found abundant in the lungs. No larvae were found in the trachea, liver, heart, spleen, kidneys, stomach, intestine, or in the masseter and lumbar muscles.

Rat A had apparently recovered from its illness on April 17th, Rat B on April 18th.

The organs of C and D were examined by serial sections. In the lungs the greater part of the air vesicles were found to be filled with red blood corpuscles. Larvae were found in the air vesicles and in the bronchi of D. No larvae were found in the other organs examined, namely, liver, kidneys, and spleen.

As a control another specimen of *Mus decumanus* albino (E) obtained from the same source as A, B, C, and D, and five specimens of the wild *Mus decumanus* and two of *Mus rattus* obtained from the town of Victoria were examined. No larvae were found in their lungs.

The Rat B was killed on April 22nd. The lungs, trachea, nasal cavities, liver, heart, spleen, stomach, and intestines were examined. No larvae or other worms were found. The lungs appeared slightly fibrosed but otherwise normal. The rat had therefore freed itself from the parasites sixteen days after the date of the first infection and twelve days after the date of the last infection.

Further experiments were made to confirm the results obtained.

On April 22nd two white rats, F and G, were given large quantities of mature eggs. Rat F was treated with the eggs of an *Ascaris* of the pig, which were eighty days old. On April 25th the treatment was repeated. On the 27th the rat was obviously ill and breathing at the rate of 134 per minute. It has continued alive, although very seriously ill, up to the date of writing—May 3rd.

Rat G was fed with eggs of the human *Ascaris* fifty-four days old. The doses were repeated on the 24th and 25th. On the 26th it was extremely ill, and breathing at the rate of 160 per minute. On the 27th it died. *Ascaris* larvae were found in the lungs and liver.*

A piebald mouse said to be one year old was treated with the same culture as the Rat G on April 24th, 25th, and 26th. On the 28th it was seriously ill, with respirations at the rate of 120 per minute. It died on that day. Lungs and liver were richly infected with larvae.*

It is interesting to compare the last experiments with Leukart's experiment with the mouse. Leukart asserted that the eggs were passed in the faeces unaltered. I found in addition to a few unaltered eggs a small number of free but dead larvae. It is probable that Leukart did not give sufficiently large doses of eggs to cause the death of the animal, and thus failed to observe the larval stages of the parasite.

Having traced the infection to the air vesicles and bronchi of the rat and mouse, it became necessary to ascertain whether the larvae in these situations were capable of further development in the definitive host.

Portions of the lungs of Rat D were administered on April 16th to the Pig B, which had been used in the experiments on direct infection described above. This animal was killed on April 30th, and stomach and intestines, heart, lungs, and liver were examined. No ascarids were found in any of these organs.

Several factors may have been responsible for this failure: (1) The larvae may require to undergo further development either in the outer world or in a second

* Sections showed that the larvae in the lungs were situated in the air vesicles, in the liver in dilated blood capillaries.

intermediate host; (2) the larvae in the lung of Rat D may have originated only from the first dose of eggs administered to it, and may therefore have belonged to the *Ascaris* of man. It is a point in debate whether the *Ascaris* of man (*A. lumbricoides*, L.) is or is not specifically identical with that of the pig (*A. suilla*, Dujardin). Infection experiments only will be able to decide this point. (3) The Pig B may have been rendered immune to *Ascaris* infection by the large doses of eggs administered to it previously. The eosinophile index of the blood was observed to rise after several of these administrations.

I do not propose to describe the larvae found in great detail in this place, as somewhat elaborate drawings are necessary for this purpose. I hope shortly to be able to publish a full account of the zoological aspects of the case in one of the zoological journals. A short summary is, however, necessary. Fig. 1 is an outline drawing of the embryo of the *Ascaris* of man expressed from an egg 43 days old, fixed with mercury perchloride, stained with haematoxylin, and mounted in Canada balsam. It is multiplied 680 times. The embryo measures 0.19 mm. The relation of the length of the oesophagus to the length of the body is 1 : 2.5. The most prominent organs are the oesophagus (*o*), the nerve ring (*n*), and the ventral longitudinal line (*v*). Fig. 2 represents a larva (multiplied 385 times) from the lung of the mouse four days after infection. It is almost identical with the embryo and measures 0.19 mm. The relation of oesophagus to body length is, however, 1 : 3.25. Fig. 3 represents a larva from the lung of the rat (multiplied 385 times) five days after infection. It shows a great advance. The animal measures 0.45 mm. The ventral line is no longer prominent and the intestine is very obvious. The ratio of oesophagus to body length is 1 : 5.

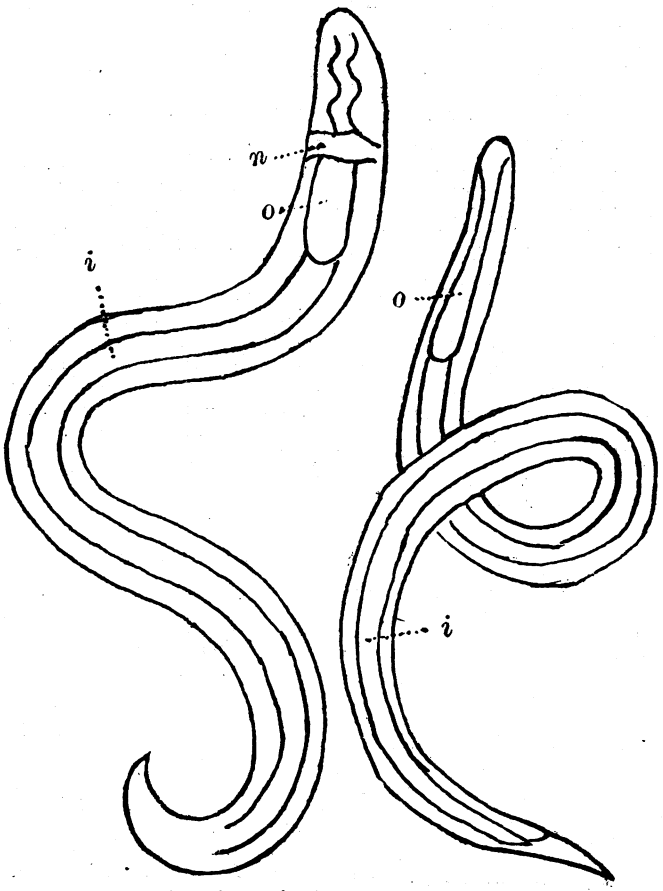

FIG. 3.—Larva from lung of rat (× 385) five days after infection. *o*, Oesophagus; *n*, nerve ring; *i*, intestine.

FIG. 4.—Larva from lung of rat ten days after infection (× 136). *o*, Oesophagus; *i*, intestine.

Fig. 4 is a drawing of the largest larva observed in the lung of the rat ten days after infection (multiplied 136 times, fixed and mounted unstained in weak corrosive sublimate solution). It measures 1.32 mm. in length. The ratio of the oesophagus to the body length is 1 : 6.

SUMMARY OF RESULTS.

The life-history of *Ascaris lumbricoides* presents an alternation of hosts. Eggs develop mature embryos in the outer world in a damp atmosphere, preferably at a temperature of from 25° to 30° C. When ripe eggs reach the alimentary canal of the rat (*Mus decumanus*) or mouse (*Mus musculus*) they hatch. The larvae liberated enter the bodies of their host, a few only escaping in the faeces. Between four and six days after infection they are found in the blood vessels of the lungs, liver, and spleen. The host is seriously ill with symptoms of pneumonia. On the sixth day they have passed from the blood vessels into the air vesicles of the lung, causing haemorrhage into them. On the tenth day they are found only in the air vesicles of the lung and in the bronchi. If the disease does not prove fatal the host recovers on the eleventh or twelfth day. On the sixteenth day the host is free from parasites.

The further course of the life-history requires further experiment for its elucidation. I have commenced experiments with this object, but among the uncertainties of military service it may not be possible to bring them to a conclusion. I therefore consider it advisable to publish the results obtained. It is obvious that the transfer of the parasite from the bronchi of the rat and mouse to the intestine of man and of the pig could be readily effected. The intermediate host might readily contaminate the food of the definitive host or the dust and earth of his surroundings.

The thanks of the writer are due to Dr. Johnson, Principal Civil Medical Officer of Hong Kong, and to Dr. Macfarlane, Government Bacteriologist, for their kindness in permitting him to use the Bacteriological Institute of Hong Kong during the prosecution of this research; to Dr. Macfarlane for much assistance, and to Mr. A. Gibson, Colonial Veterinary Surgeon, Hong Kong, for great help in the supply of material.

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IN a communication made to the Medico-Chirurgical Society of Bologna last February, and since published in the *Bollettino delle Scienze Mediche*, Professor Benedetto Schiassi described an apparatus devised by him for the better transport and treatment of patients suffering from fracture of the lower limbs. From the photographs it would appear that the splint is something between a Hodgen and a Thomas's splint; it consists of three parallel metallic rods, from which extension and counter extension can be made; these are joined at the lower end by arches and cross bars, and at the upper end have a firm moulded support to encircle half the pelvis. One of the photographs shows that the transport of a patient is much facilitated and the injured leg kept well fixed, while ample room is allowed for the application of dressings. By means of pins driven into the os calcis and hooks and elastic bands extension can be used in any desired degree, and as this is independent of bandages, the limb keeps its position when the wounds are dressed. Apart from fractures, the splint is useful for fixing a limb in arthritis. Massage can also be carried out without disturbing the splint. The price is 40 to 50 lire. Schiassi affirms that by his splint the transport of soldiers with fractured lower limbs is effected safely and securely.